

AD-A121 370

LIFE CYCLE TRAINING COSTS: A LITERATURE REVIEW (U) NAVY
PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN DIEGO CA
J R SKEEN ET AL. APR 81

171

UNCLASSIFIED

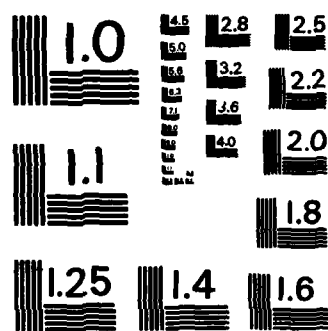
F/G 5/9

NL

END

FORMED

DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

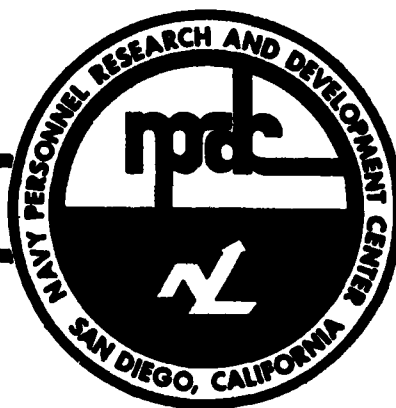
AD A121370

DTIC FILE COPY

NPRDC TN 81-10

APRIL 1981

**LIFE CYCLE TRAINING COSTS:
A LITERATURE REVIEW**



**NAVY PERSONNEL RESEARCH
AND
DEVELOPMENT CENTER
San Diego, California 92152**

This document has been approved
for public release and sale; its
distribution is unlimited.

NOV 9 1982



**LIFE CYCLE TRAINING COSTS: A
LITERATURE REVIEW**

James R. Skeen
Alfred E. Jackson

Hughes Aircraft Company
Los Angeles, California 90009

Reviewed by
Ernest A. Koehler

Approved by
Richard C. Sorenson
Director of Programs



A

Navy Personnel Research and Development Center
San Diego, California 92152

82 11 09 105

FOREWORD

This literature review was performed in support of Navy Decision Coordinating Paper, Manpower Requirements Development System (NDCP-Z0109-PN) subproject Z0109-PN.03, Manpower Cost in System Design, and under the sponsorship of the Deputy Chief of Naval Operations (OP-01). The objective of this subproject is to reduce the manpower requirements and the associated life cycle costs of new hardware systems. Information and techniques are being developed to assist hardware developers in assessing the people-related implications of their designs and for conducting cost-effectiveness analyses during the design process.

This literature review was the first step in developing a training-system life cycle cost model and a supporting data base. The purpose of the training system cost model is to identify those training elements having significant cost implications for initial and follow-on hardware system training. Through the use of such a model, training costs can be predicted and used in early cost-effectiveness studies to assess more accurately the cost implications of alternative hardware systems.

This literature review was conducted in 1978 and subsequently utilized in improving the Navy's Enlisted Billet Cost Model. It is documented at this time to make it available to the research community.

The contracting officer's technical representative was Mr. John F. Brock.

RICHARD C. SORENSON
Director of Programs

SUMMARY

Problem

Training costs have been an increasing contributor to the life cycle costs of military weapon systems. As the concept of training has broadened and alternative approaches to training have become available through the development of new technologies, the difficulties of determining and projecting training costs have increased.

Purpose

The purpose of this effort was to provide background and materials for use in the construction of a life cycle training costs model for determining the cost of training associated with the life cycle of Navy weapon systems.

Approach

The literature selected for review was organized into three subject areas: (1) system-oriented life cycle training, (2) instructional systems development (ISD), and (3) costing.

Findings and Conclusions

1. Existing models of major system acquisition and support apparently are adequate for establishing general training requirements and training development plans.
2. Training is a minor cost factor, compared to other elements in the acquisition and support systems, partly because the training spelled out in these models is the factory training that takes place during system development and initial deployment. Any follow-on training is considered to be simple iteration of the factory course. Training efforts up to the point of system production are, in fact, insignificant compared to the hardware-oriented efforts.
3. Actual CNET responsibilities tend to develop rather late in the system acquisition cycle. Even in the training plan development, they have only a supporting role.
4. The training required by system support personnel tends to be ignored.

5. Increasingly sophisticated ISD models have been developed. Instructional development processes have been defined in great and useful detail. The current evolution of these models, however, is strong in the middle phases of the process, but weak in initial training requirements and system planning efforts. These models are also strong in the areas of content identification, media development, and student handling. Conversely, they are weak in the areas of instruction, equipment, and facility requirements, as well as in instructional-system evaluation, revision, administration, and support.

6. Part of the lack of emphasis on the development of the other elements may stem from the fact that these development models do not define a total instructional system.

7. If ISD is to become what the name implies, instead of just the systematic development of instruction, the development process will need to be expanded to encompass the entire instructional system.

8. Inadequate attention has been paid to the costs of establishing training requirements and plans early in the system acquisition process.

9. Most efforts have addressed only the initial development and one-time presentation of instructional material. Course repetition costs do not address problems of revision or redevelopment of instructional materials or the time gaps between course repetitions.

10. When base or other support costs are presented, there is very little detail.

11. At this time, there appears to be more disparity than uniformity in costing approaches, levels of details given, categorization of systems used, and cost areas included.

12. The diversity in approaches found in the literature may be due to the differing needs of the individuals involved in the training process: The initial planners in the principal development agency, the training development specialists, and those who manage and conduct the training operations.

CONTENTS

	Page
INTRODUCTION	1
Problem	1
Purpose	1
APPROACH	1
LITERATURE REVIEW	2
System-Oriented Life Cycle Training	2
Weapon System Acquisition.	2
System-Oriented Life Cycle Cost Models.	3
Current Ship Acquisitions	4
Pertinent Government Publications	5
Instructional Systems Development	5
Training Model	6
Method of Designing Instructional Alternatives (MODIA)	8
Selecting Cost-Effective Methods and Media	9
Interservice Procedures for Instructional Systems Development (IPISD)	9
ISD Applications	10
Additional Elements of Instructional Systems	11
Costing	12
Procedures.	12
Costing Methods	13
Cost Elements	16
On-the-Job Training (OJT)	18
DISCUSSION	18
CONCLUSIONS.	20
REFERENCES	23

INTRODUCTION

Problem

Training costs have been an increasing contributor to the life cycle costs of military weapon systems. As the concept of training has broadened and alternative approaches to training have become available through the development of new technologies, the difficulties of determining and projecting training costs have increased.

Purpose

This literature survey is the first step in the development of a model to describe all of the training required to develop, man, and support a given weapon system during its life cycle. This model will be used to determine all the training costs incurred during the lifetime of a weapon system.

APPROACH

The literature reviewed came from a number of sources and was identified principally by four major literature searches. Prior to the start of this program, a Defense Documentation Center (DDC) (now Defense Technical Information Center, DTIC) search was made using key words in the area of training costs. This was supplemented in the early part of the program by a second DDC search, a National Aeronautics and Space Administration literature search, and a dialog-on-line retrieval bibliography search using such key words as training models, instructional systems development (ISD), and systems approach to training. Nearly 100 potentially appropriate items were ordered from these lists and, except for a few limited distribution documents, all were eventually received. The additional documents acquired were identified from surveys of the literature acquired, from miscellaneous contacts, and from sequential tracking of Department of Defense (DoD) and Navy documents and instructions.

The literature selected for review was organized into three broad overlapping areas:

1. System-oriented life cycle training, including information about the kinds and timing of instruction during system acquisition and deployment, the integrated logistic

support (ICS) development process, and the life cycle costing approaches that have been evolving in these areas.

2. Instructional systems development, including the nature and operation of instructional systems and the ISD process.

3. Costing, including general costing considerations, costing conventions used in the system acquisition process, and ongoing efforts to determine training costs.

LITERATURE REVIEW

System-Oriented Life Cycle Training

Weapon System Acquisition

In the early 60s, DoD began to emphasize the support characteristics of weapon-system acquisitions. Historical records had revealed that the acquisition of a weapon system involved far less money than its operation. The operational support characteristics of a weapon system, which include such elements as maintainability, reliability, training, and technical publications, are currently classified as the integrated logistic support (ILS) concept. The ILS literature seldom stresses training methods or cost in system design. The emphasis appears to be on hardware reliability. As an example, Patterson (1971) discussed training as an ILS category, but then omitted it entirely in the costing guidance section.

In the Naval Air Systems Command (NAVAIR) system acquisition process, the only reference to training is in regard to the responsibility of naval engineering laboratories to provide technology training, on a consultant basis, to the system project office (Ottaviano, 1973). Perschbacher (1974), in another Navy study on life cycle costing (LCC), was concerned only with the funding of initial training.

In an Air Force study of the aborted procurement of the SCAD missile, Kollin (1966) described the early-stage problems of a training special project office. The costly effects of limited system information and short lead times provide lessons in what to avoid in future acquisitions. In a state-of-the-art study in LCC by Walker of the Boeing Company

(1974), only initial contractor-provided training is included in the 14 electronic data processing (EDP) models studied. An interesting conclusion of this study is that LCC models do not provide realistic cost figures.

One of the approaches in LCC is design to cost, which was described by Hackett, Monroe, Galin, Marecki, and Schotzman (1975). This study provides a clear explanation of the acquisition process.

A 1977 study by Berard concentrates on operating and support costing in three ongoing hardware acquisitions: F-18 (Navy), ARC-164 (Air Force), and Blackhawk (Army). Apparently, training was not a problem in these acquisitions, since Berard discusses only other ILS problems and the techniques involved to solve them.

System-Oriented Life Cycle Cost Models

The Air Force Logistics Command model (1975) utilizes system operational service life, mean time between failures, and the maintenance concept to determine the number of personnel to be trained for base and depot facilities. The model does not include operator or support personnel training. Course length, training cost per hour, and cost of training equipment must be provided by the model user.

Two cost-of-ownership models (Litton Systems, Inc., 1976; Boeing Company, undated) are very similar to the Air Force Logistics Command model. Both require training information as input terms. Operator, support, and instructor personnel training are not included.

The training section of the Naval Weapons Engineering Support Activity model (1975) is the most detailed of any of the LCC models reviewed. In this model, which is indexed to the MIL-STD-881 work breakdown system, training is divided into test and evaluation (T&E), initial, and recurring segments. Operator and technician training includes military and civilian personnel. Facilities, training aids, training material, and travel costs are included as elements. Some of the model limitations are that: (1) the number of students must be supplied, (2) system and training-support personnel training and utilization are not

included, and (3) model terms, such as standard course fee and weekly course fee, are not defined.

The Army model is in EDP format (Army Electronics Command, 1975). Its primary purpose is to determine ILS cost for electronic equipment. A unique feature of this model is the use of training-cost-for-manpower as one of the variables in the sensitivity analysis. The cost per military occupation specialty (MOS), training time, and time between training are all input terms to be provided by an unidentified source.

Two other models--those developed by Gay and Nelson (1974) and Rome Air Development Center (1976)--also require input terms that training model should generate, such as training cost per manweek, training manweeks, and recurring training factors. The Gay and Nelson model includes initial training by the contractor.

Current Ship Acquisitions

A life cycle manpower cost methodology was developed in 1968 for the Amphibious Assault Ship (LHA) (Taylor, 1968). For that time period, the model is quite comprehensive for a complex weapon system. The Taylor (1968) paper contains one of the few discussions of officer costs. The LCC model has divided the enlisted personnel into five functional groups, and per capita cost figures are utilized to compute total personnel costs. The paper and its appendices provide detailed equations, cost collection forms, cost factor/category definitions, and cost tables available at that time (1967) from various Navy sources. This study was conducted between Defense Systems Acquisition Review Council (DSARC) I and II.

The Destroyer (DD 963) literature does not include costs, but is of interest as an example of a modern ship acquisition (DD 963 Integrated Logistic Support Plan, undated; Litton, 1974, 1975). LCC models and training models typically do not include the cost of preparing this type of documentation during the training requirement and planning phases. These documents list the number of contractor, Navy, and advisory service courses required for each ship. They required 4 years to compile and, since they were produced by the contractor, the recorded costs should be available for future system managers.

Pertinent Government Publications

The government publications listed in Table 1 were reviewed to discern the acquisition and operation of the training function in a weapon system. The number of documents reviewed was limited by their availability through DTIC.

Collectively, these documents were reviewed to identify the functions and organizations involved in Navy weapon system training. In this structure, the key document is OPNAVINST 1500.8H, which describes the tasks of developing Navy training plans (NTP). Appendix C of OPNAVINST 1500.8H is a sample NTP that identifies responsible agencies.

Circular A-109 from the Office of Management and Budget is written at a policy level; therefore, its impact on Navy training will not be evident until it is interpreted and implemented by Navy procedural documents. However, circular A-109 institutes additional control on the acquisition process by using the mission element need statement document and adding a decision point (Milestone 0). This will emphasize front-end analysis and will require early and accurate input from training managers. The test and evaluation phase is expected to become more stringent with increased requirements for trained personnel.

Instructional Systems Development

Two models are needed to bring order to the problems of instructional costing. The prominent one is the instructional systems development (ISD) model, which defines the process of developing instruction from determining course requirements through course revision. This kind of model focuses primarily on the content and delivery of the instruction. This emphasis is appropriate, since effective instruction is the most basic requirement of all instructional programs. The second model, which may be more appropriate to the process of costing instruction, is a model of the instructional system that includes all of the elements and activities required to conduct instruction. Although it is usually assumed that such a model falls out of ISD models, it rarely does. In the case of ongoing instruction in established schools, the system is the entire school, which is

Table 1
Some of the Government Publications Related to
Navy Training

Title	Date	Subject
OMB Circular A-109	5 Apr 76	Major system acquisitions
DOD 4100.35G	1 Oct 70	Development of integrated logistic support for systems and equipments
DOD 7041.3	18 Oct 72	Economic analysis and program evaluation for resource management
MIL-STD-1379A	1 Oct 76	Contract training programs
SECNAVINST 5000.1	13 Apr 72	System acquisition in the Department of the Navy
SECNAVINST 7000.14B	18 Jun 75	Economic analysis and program evaluation for Navy resource management
OPNAVINST 1500.2E	3 Apr 73	Establishment and coordination of factory training programs for military and civilian personnel; responsibilities and procedures for
OPNAVINST 1500.8H	3 Jul 75	Preparation and implementation of Navy training plans (NTPs) in support of hardware and nonhardware oriented developments
OPNAVINST 1500.19C	7 Jul 72	Authority and responsibility of Fleet Commanders in Chief for naval training activities ashore
OPNAVINST 1500.44	24 Oct 73	Responsibilities for development of training requirements and training plans
OPNAVINST 3500.23B	5 May 72	Assembly, organization, and training of crews for U.S. Navy ships commissioned in time of peace
OPNAVINST 4490.2B	13 Apr 70	Availability of equipment for training purposes
OPNAVINST 4700.12C	20 May 70	Responsibilities in development of Navy shipbuilding and conversion programs
OPNAVINST 5000.42A	3 Mar 76	Weapon system selection and planning
OPNAVINST 5300.3A	25 Sep 75	Development and review of enlisted manpower requirements in naval ships
OPNAVINST 9860.5	3 Jun 68	Incorporation of self-contained training capabilities into shipboard equipment and systems
NAVMAT P-4000	March 72	ILS implementation guide for DoD systems and equipments
NAVMATINST 1500.2C	17 Apr 75	Preparation and implementation of Navy training plans for new developments
NAVMATINST 4000.20B	27 Jun 75	Integrated logistic support planning policy
NAVMATINST 5311.2A	2 Nov 76	Military personnel and training requirements
NAVMATINST 5311.3	5 Sep 74	Personnel and training analyses office; utilization of
NAVSEAINST 1543.1	Unknown	Manpower, personnel, and training support for NAVSEA cognizant ship, system, equipment, and nonhardware developments
NAVSEAINST 4105.1	22 Jul 77	Integrated logistic support (ILS); policy, responsibilities, and planning
CNETINST 1500.9	26 Jun 74	Participation by the Naval Education and Training Command in the preparation and implementation of Navy training plans

usually taken as a given by the ISD activities revising old courses or creating new ones. In the case of system-oriented instruction, any new instruction required must be addressed in terms of developing an entire instructional system, not just the student-oriented aspects. An instructional costing model must address design and development, not only of the instruction itself, but also of administration, support, and required noninstructional facilities. An adequate instructional costing model, then, should somehow encompass the instructional system and its development and operation.

An extensive literature base exists in the general area of instruction and ISD. One bibliography published by Schumacher, Pearlstein, and Martin at the beginning of 1974 contained 2692 items pertinent to ISD. The majority of this literature addresses the difficult areas of content development, methods of delivery, and instructional strategies. Some of it involves the process of developing effective instruction efficiently.

To develop a model for determining the life cycle costs of system-oriented training, however, almost all of the literature cited appears to be inappropriate. Much of it concerns the learning process itself, civilian education, or details of instruction and alternative instructional delivery techniques. Even if the subject matter is identified as involving systems--as in the instructional systems or training systems development literature--it usually is used in the sense of a systematic approach to instructional development.

Training Model

A training model addressing the problem of improving effectiveness in some areas of Army training was developed in a series of four articles by Weingarten et al. (Weingarten, Hungerland, Brennan, Allred, and Pollyea, 1970; Weingarten, Hungerland, Brennan, & Allred, 1970, 1971; Weingarten, Hungerland, & Brennan, 1972). This model addresses the nature of a course. The course is analyzed into content modules (i.e., blocks of instructions). Each module is then organized into a sequence of instructional activities that culminate in peer instruction and course administration assistance. The approach

was used on a specific course. Comparisons between this new course and the prior one are based on differences in average training days required and estimates of cost per man-day of training.

The Weingarten model illustrates some of the problems of attempting to apply the general literature to the current program. As this model represents the specific instructional strategy of using peer instruction, it is not generally applicable. The existence of a system to provide the necessary personnel and materials to administer, support, and conduct the instruction is assumed. Hence, the model is oriented to the systematic development and conduct of the instruction, rather than to the development of an entire instructional system. Finally, the detail of the cost evaluation is only sufficient to determine the cost differences between the new and prior courses; it is not sufficient to determine the total course costs in either format.

Method of Designing Instructional Alternatives (MODIA)

A much more detailed approach (Petruschell, 1972) was developed in the Rand Corporation's Method of Designing Instructional Alternatives (MODIA) program for the Air Force. Petruschell (1972) presents a demonstration by applying this approach to the redesign of an Air Force course in basic photography. MODIA is oriented to detailed course design using ISD procedures to evaluate instructional alternatives and also has a highly sophisticated set of costing procedures. Costs are included for direct support, administration, and indirect support. The cost analysis is sufficiently detailed for subsequent computerization.

Even this elaborate approach falls short in some areas, however. Two models really were developed. The instructional systems design model describes course design and development, but does not describe the instructional system. The costing model categorizes the operation of the course in detail, but does not explicitly describe the instructional system either, since it assumes that this course is in one of the departments of an operating school. In addition, the course design and development process is not part

of the costing model. The instructional design model also assumes the existence of a school and the requirements for, and general structure of, the course. The front-end analysis and planning activities needed for the course development are not part of either model.

Selecting Cost-Effective Methods and Media

Spangenberg, Riback, and Moon (1973) reviewed the status of selecting cost-effective methods and media for training and presented an excellent analysis of costing problems and approaches. The instructional methods and media-selection procedures available at that time were not really adequate to the Army's problem, because they were either too simplified or too complicated. To a large degree, this is also true for applying the existing literature to the development of a system-oriented life cycle training model. Even in areas where submodels might be assimilated, they tend to be either too detailed or too gross to be directly useable.

The Training Effectiveness and Cost Effectiveness Prediction (TECEP) model, which was developed by the Training Analysis and Evaluation Group (TAEG) at the Naval Training Equipment Center (NTEC), goes a long way toward overcoming these difficulties by attempting to organize the complicated details of content characteristics and media capabilities into categories, thus simplifying the media-selection process without losing meaningful detail (Braby, Henry, Parrish, & Swope, 1975). The TECEP model was developed to fit into the Interservice Procedures for Instructional Systems Development (IPISD) model (see following section) and, consequently, deals neither with the entire instructional system nor the entire development process. As a component of a life cycle training model, it has the drawback of being a prescriptive or directive model that is designed to give relatively specific guidance to the media selection process.

Interservice Procedures for Instructional Systems Development (IPISD)

The most important milestone in the ongoing evaluation of the instructional systems development process to date was the publication of the IPISD in 1975 (Branson, Rayner,

Cox, Furman, & King, 1975a, b, c, d, e; Branson, Rayner, Furman, & Cox, 1975). The procedures were accepted as the definitive guides for the development of new training by all services. In the Navy, even factory training is to be developed in accordance with its procedures. Basically, this development process model attempts to combine the best of earlier instructional development approaches into five major phases: analyze, design, develop, implement, and control. Detailed guidance is presented for the activities in each phase. Because it has been accepted by all of the services (particularly the Navy), it seems highly desirable to use this model as the basis for the system-oriented life cycle training model. As with the previously noted models, however, there is no clear or explicit model of the instructional system itself. In line with this omission, the model tends to emphasize the development and delivery of the instruction.

The model does give attention to other necessary system elements such as instructors, equipment, facilities, and, to some degree, system administration and support. However, these factors are treated only in their immediate relationship to instructional delivery. Another positive attribute of the model is that, in the development areas covered, ancillary activities of the developing agency are identified as management decisions and may be used as guidance for development costing. In general, the IPISD model is an attractive candidate to be used for guidance in the formation of the system-oriented life cycle training model.

ISD Applications

Three recent applications of ISD procedures for developing training for specific weapon systems involved the development of aircrew training for the A-6E, the S-3A, and the E-2C Navy aircraft (Bromberger, 1977; McLachlan, 1977; Sugarman, Johnson, Mitchell, Hinton, & Fishburne, 1976).

Although the S-3A program (McLachlan, 1977) was started and largely carried out before the publication of the IPISD model, development activities are consistent with it. The procedures used to develop new instruction for the A-6E training were an amalgamation of past ISD approaches and the relevant procedures from the IPISD model. These were all in essential agreement.

The E-2C program was carried out as an extension of the ISD procedures developed by the Calspan Corporation in their B-1 systems approach to training efforts (Sugarman, Buckemaier, & Johnson, 1974), which were consistent with the procedures of the IPISD model. As with all of the ISD models and programs cited here, the major emphasis was on the development of the instruction, while the instructional system was assumed to be adequate to conduct and control the instruction. Again, the assumed nature and elements of such a system must be inferred.

Of special interest in the E-2C and A-6E reports, however, were efforts to cost the instructional developments involved. The E-2C program costed four activities--planning, task analysis, training-objectives development, and lesson specification and instructional delivery method--in terms of the estimated manpower and travel costs. In the A-6E report (Bromberger, 1977), manpower was estimated for five technical activities (planning, task analysis, specific behavioral-objectives development, media analysis, and lessons specifications), as well as for preparation of the program final report. Travel and data-computing services costs for the entire program were also given. Although these exercises are fairly rudimentary and estimates, rather than exact calculations, were used, they at least point to the possibility of estimating costs of developing instructional system elements.

Additional Elements of Instructional Systems

The recent literature reinforces the need to categorize all the elements of an operating instructional system, as well as the structure of the developmental process. Orlansky and String (1977a) analyze the role of simulators in aircrew training. Full-mission simulators have become increasingly expensive as the prime systems in this area have become increasingly complex. Although they do not require their own DSARC-keyed cycles, they require design and support development that is as complex as many other full system developments. If they are considered as instructional media--which they basically are--the size of the instructional delivery element of the instructional system is

increased enormously. They also require major development and operation activities in the support element of the instructional system, including maintenance activities, significant spares and provisioning activities, and a programming or reprogramming capability. The instructional system administrative element will also be enlarged accordingly.

The problems of evaluating instructional systems were addressed by Hall, Lam, and Bellamy (1976) and Hall, Rankin, and Aagard (1976). The thrust of these reports is that the Navy--as well as the other services--must increase its evaluation of instructional system effectiveness to ensure the cost effectiveness of instructional systems. Both the potential for increasing combat readiness and ensuring maximum effectiveness for each training dollar spent justify formalizing the instructional system evaluation element and allocating funds for providing evaluation feedback from the operational units to the instructional system.

Costing

Procedures

Successfully determining the cost of any system depends upon the analyst's interpretation of cost and how completely the system is defined. G. H. Fisher (1971) stresses the use of economic cost, where the use of resources in one program represents a cost since these resources cannot be used in other programs. In this light, most existing training models are incomplete, in that they do not include costs of management, administrators, planners, and the like.

Fisher also recommends the use of dollar costs as a measurement tool to select and compare alternatives. The use of dollars, however, to quantify elements in a training course is extremely hazardous. Cost-Effectiveness: The Economic Evaluation of Engineered Systems (edited by J. M. English, 1968) contains an excellent section on cost-effectiveness fallacies and misconceptions that should be reviewed by anyone determining or evaluating the cost of training courses.

In 1976, Navy training was analyzed by Doughty, Stern and Thompson, as well as by Swope. Both reports provide specific guidance and procedures for costing Navy training. Doughty et al. (1976) also provide samples of cost-collection and organizing forms and cost analysis of the Navy Interior-Communications Electrician School and of the Army training extension course system.

Costing Methods

Training Effectiveness and Cost Effectiveness Prediction (TECEP). At the time of this writing (1978), the most current and comprehensive training course model is the TECEP model developed from 1972 to 1975 by TAEG (Braby, Micheli, Morris, & Okraski, 1972, Braby, Henry, et al., 1975; Swope, 1976). The TECEP model is designed to evaluate a single program (course) of instruction and would have to be iterated to encompass a total weapon system training program. The iteration process is feasible since the model has been adapted (FORTRAN IV) for electronic data processing.

The usefulness of the TECEP model is somewhat limited because it omits management, administration, and other support costs, as well as such operating costs as transportation, communications, and technical manuals. Braby et al. (1975, p. 77) also state that "the model (TECEP) is not designed to predict or forecast the total cost of a system for which a planner must budget resources."

A study conducted by Honeywell's System and Research Center for the Naval Air Development Center (Daniels and Cronin, 1975) utilized the TECEP model to compare automated electronic maintenance training (AEMT) with the use of operational hardware for maintenance training. One of the unique features of this study was the use of a joint NAVAIR/Honeywell team to obtain Navy training cost data. This arrangement was required since the TECEP model does not provide cost sources.

The MODIA Technique. The operation of MODIA was demonstrated in an Air Force basic photography course (Petruschell, 1972). The study is of interest for basically two reasons: First, the course utilized the self-paced format that is becoming more prevalent

in military training and, second, a student flow simulation technique was applied to determine the demand for essential resources. The costing procedures for base facilities and administrative personnel are especially comprehensive, but the media maintenance manpower and curriculum manpower costs are only assumptions.

The MODIA technique is useful from a life cycle cost viewpoint in that it provides investment (development) and annual operating costs based on a particular student flow. The cost of determining the training requirements and the planning (which in this case would be the cost of the study) are omitted. Also, the annual operating costs may not be valid for an extended period of time, as technological changes in both operational equipment and instructional methodology occur.

Undergraduate Pilot Training (UPT). A model for undergraduate pilot training (UPT) for the Air Force was presented by Allison (1969), Boren (1969), and Littleton, (1969). Cost projections for this training from 1975 to 1990 are given by the Mission Analysis Study Group (1972). The Air Force UPT model only covers the conduct of training and ignores its development, planning, and requirements. Its value for costing Navy training is primarily in the degree of detail in costing; for example, hundreds of cost elements are combined to form 228 input terms that are used to calculate an 11-page list of variables. This list of cost elements provides an excellent checklist for costing any training course.

The UPT model contains two features that are particularly noteworthy in the field of cost modeling. First, to reflect total Air Force training costs, the costs of depot maintenance of training aircraft--not funded by the Air Training Command--are included. Second, investment costs are reported in the year the item is delivered. This may distort the cost-per-graduate figures for some years, but is realistic from a funds-expenditure timing point of view. It is difficult to incorporate an amortization scheme that would satisfy all model users.

Fleet Readiness Training (FRT). The operation of the Fleet Readiness Training (FRT) model, which is the pilot training model for the Navy, is described by Kyle, Craig, Fish,

Ligget, and McCoy (1971a, b, c, d, e, f). The FRT planning tool, which has been in daily use by the Aviation Training Division of CNO since October 1970, contains the methodology to estimate 75 percent of the total system cost of the pilot training program after the costs of military personnel and aircraft acquisition have been deducted.

Army. Weinberg (1967) attempted to overcome the insufficiencies of school costing revealed by Kollin (1966) in a study of service school cost and recording practices by determining gross cost figures. Utilizing the training allocations of the Military Personnel Army (MPA), Operation and Maintenance Army (OMA), and Military Construction Army (MCA) budget authorizations, the study developed per capita training cost for individual military occupational specialties. These costs were then added to provide training costs for the nine DoD occupational areas.

Spangenberg, Riback, and Moon (1973) conducted a literature study to determine the state of knowledge of selecting cost-effective training methods and media. This study emphasized the need for specific cost-accounting structures pertaining to Army training. The paper discusses basic mathematical formulas for use in cost analysis and demonstrates a procedure for comparing old and new courses by utilizing expected utility values to compute cost-effective indexes.

General. Thompson¹ presented an interesting method of comparing instructional alternatives and described the problems and complications that arise when comparing instructional alternatives. The cost collection forms and some of the calculations are found in Doughty, Stern, and Thomson (1976).

Since 1972, the U. S. Civil Service Commission has utilized a training cost model (Mirabal, 1978). This model was probably not intended for technical training courses in its present form, since little mention is made of equipment and equipment-related support costs.

¹Thompson, C. Comparison of instructional alternatives from an economic point of view (NPRDC memo 201-M-239CJT). San Diego: Navy Personnel Research and Development Center, 1975.

The worksheet format and manual calculation process provided in the model, however, could be used to predict the costs of small infrequently-conducted weapon system training courses, where EDP cost collection is impractical. The command ILS training requirement or some of the training conducted in the early weapon-system life cycle are examples of where this method might be applied.

Two TAEG studies (Copeland, Nutter, Dean, Curry, & Morris, 1974; Copeland, Nutter, Henry, Swope, & Curry, 1975) were conducted to investigate alternative methods of providing Navy skill training. Although the reports do not contain much on actual costs, they do describe several billet training requirements in detail. The economic cost analysis forms included in the studies might serve as checklists for training planners.

Cost Elements

Many of the training-course cost models require cost element data as input; for example, personnel costs are usually included in a single term describing salary and benefits of applicable personnel. Fortunately, the determination of some of these cost elements is the specific subject matter of several studies.

The various cost elements are discussed below:

1. Personnel. Several reports are concerned with the determination of personnel costs (Bellanca, 1975; Clary, 1968; Clary & Creaturo, 1971; Connelly, 1966, 1967; Martin, Koehler, Mairs, & Hogan, 1977). The most useful publication is the Life Cycle Navy Enlisted Billet Cost Tables--FY77 (Martin et al., 1977), which provides life cycle costs information for Navy enlisted personnel by ratings and pay grades in 1-, 5-, 10-, 15-, and 20-year increments.²

The only cost data discovered for officers were published in 1971 (Clary & Creaturo). Work on a current officer cost model is planned through the Navy Personnel Research and Development Center (NAVPERSRANDCEN).³

²Editor's note: For latest data, see Koehler, E. A. Life cycle Navy enlisted billet costs--FY80 (NPRDC SR 80-7). San Diego: Navy Personnel Research and Development Center, January 1980.

³Editor's note: See Koehler, E. A. Life cycle officer billet costs--FY80: An interim report (NPRDC SR 80-18). San Diego: Navy Personnel Research and Development Center, May 1980.

This particular literature search did not reveal any studies providing cost data for Civil Service personnel (GS and WB classification). NAVPERSRANDCEN has recently begun an effort to provide a civilian billet cost model.⁴

2. Facilities. While most training costing models include facility cost as an input item, they seldom provide cost determination information. Goodyear (1965, 1966), as well as Wethy and Bumbak (1971), provide lists and explain several factors of facility costs. The general consensus is to amortize the construction cost over the facilities' useful life and, then, use replacement cost figures.

3. Simulators. Simulators have been the subject of many studies. Historically, these studies have focused on flight training simulators, but the evolution of computer hardware, software, and display techniques has introduced simulation into maintenance training as well (Brock, 1978).

The complexity and high costs of simulators (both investment and operating costs) require thorough front-end analysis of needs and economic constraints. The B-1 systems approach to training (Reif & Ring, 1975) is an excellent example of training planning and cost expenditures during the R&D phase of modern weapon systems. The B-1 study should also be of value to training managers because of the application of ISD in the program.

Another flight simulator study (Orlansky & String, 1977b) contains a comprehensive training cost model that provides both investment and operating costs. The model detail includes administrative costs for both training and base support personnel. The model does not include construction costs; the authors state that, "in relation to the life cycle costs (or life cycle training costs) of the system the simulator supports, construction costs can be anticipated as a minor item."

⁴Editor's note: See Koehler, E. A. Navy civilian (civil service) billet costs--FY80: Interim report (NPRDC SR 80-19). San Diego: Navy Personnel Research and Development Center, May 1980.

4. Media. Using 1970 figures, Rhode, Esseff, Pusin, Quirk, and Shulik (1970) provide an extensive list of media costs. The list contains dollar costs for various media from display systems to text books.

5. Equipment. Three studies are of interest in the area of training equipment. The study prepared by Lintz, Loy, Hopper, and Potempa (1973) is concerned with avionic subsystem design and training and also includes a discussion of training equipment costs. Thompson⁵ provides fairly recent equipment costs in the area of computer-managed instruction, as well as civil service personnel salary costs. Davis (1977) provides 1977 costs of micro, mini, general purpose, and dedicated (TICCIT and PLATO) computer systems.

On-the-Job Training (OJT)

Several studies on the costs of on-the job training (OJT) were reviewed: Arzigian (1967), Weiher and Horowitz (1971), Dunham (1972), Gay (1974), Gay and Nelson (1974), and Samers, Dunham, and Nordhauser (1974a, b). OJT costs seldom appear in training cost models primarily because they are not funded in training budgets.

Two studies—Arzigian (1967) and Weiher and Horowitz (1971)—provide costing procedures and list OJT costs by Navy rating. The 1971 cost figures are as current as most of the other element costs found in the literature. It is interesting that most of the studies address the efficiency and cost effectiveness of OJT versus formal school training. The studies consistently show that formal school training provides trained personnel in a shorter time and at less cost.

DISCUSSION

All of the literature reviewed pertained to the general area of training and training development; and most of it, to the more specific area of training required by military systems. However, there was a great diversity as to problems addressed, viewpoints

⁵Thompson, C. Cost comparison: CI versus CMI (NPRDC memo 201-M-121CT). San Diego: Navy Personnel Research and Development Center, August 1975.

taken, approaches used, and models developed. This diversity may result from the differing backgrounds and orientations of the three groups of people who are involved with a system-oriented training course during its life. The first group consists of people from the principal development agency, who establish training requirements and develop the training plan. Although they have some understanding of training development and operations, they are oriented to prime system development, deployment, and support. They establish, at a general level, the kinds, amounts, and timeliness of the training required for a successful system acquisition. In a real sense, they are user-oriented. They work under the pressures appropriate to the early stages of the weapon system acquisition cycle and are likely to give primary attention to the early training necessary for system test and evaluation and initial system deployment.

The second group consists of training development specialists, who translate the general training requirements established by the first group into specific course content requirements, and develop the instructional materials and strategies required to carry out the training. In the past, these individuals were frequently instructors, who might also conduct the training. Increasingly, with the expansion of training technology, specialists develop instruction and leave the training to others. Also, they are becoming more oriented to the training development and delivery systems, rather than to the overall operation of the training system. Their goal tends to be the establishment of learning effectiveness.

Finally, the third group consists of the individuals who conduct and control the actual training. They are the administrators, instructors, and support personnel that manage, operate, evaluate, and revise the training system. They are oriented to the effectiveness of the training, and also to the efficiency of the day-to-day training system operations. Their concerns are not limited to the actual instruction, but include scheduling, personnel handling, equipment and facility management, recordkeeping,

budgeting, and all additional facets of operating an instructional system in a military training environment. Their goal is to operate a cost-effective training system.

In earlier times and with simple systems, the same individuals might have performed all three functions successively. In current major military systems, they often are in the three separate groups named, each of which receives funds from different sources and works in a different command.

A system-oriented life cycle training model is needed to provide a coherent structure for the viewpoints, goals, and activities of these three groups and to provide each group with the costing information it needs. More specifically, the model should encompass all of the training required from initial system development support through initial crew training to follow-on replacement training.

CONCLUSIONS

1. In system-oriented life cycle training, existing elaborate models in the area of major system acquisition and support apparently are adequate for establishing general training requirements and training development plans.

2. Training is a minor cost factor, compared to other elements in the acquisition and support systems. Training costs appear to be minor, partly because the training spelled out in these models is the factory training that takes place during system development and initial deployment. Any follow-on training is considered to be simple iteration of the factory course. Training efforts up to the point of system production are in fact insignificant compared to the hardware-oriented efforts.

3. Actual CNET responsibilities tend to develop rather late in the system acquisition cycle. Even in the training plan development, they have only a supporting role.

4. The training required by system support personnel tends to be ignored.

5. Increasingly sophisticated ISD models have been developed. Instructional development processes are defined in great and useful detail. The current evolution of these

models, however, is strong in the middle phases of the process, but weak in initial training requirements and system planning efforts. These models are also strong in the areas of content identification, media development, and student handling. Conversely, they are weak in the areas of instruction, equipment, and facility requirements, as well as in instructional-system evaluation, revision, administration, and support.

6. Part of the lack of emphasis on the development of the other elements may stem from the fact that these development models do not define a total instructional system.

7. If ISD is to become what the name implies, instead of just the systematic development of instruction, the development process will need to be expanded to encompass the entire instructional system.

8. Inadequate attention has been paid to the costs of establishing training requirements and plans early in the system acquisition process.

9. Most efforts have addressed only the initial development and one-time presentation of instructional material. Course repetition costs do not address problems of revision or redevelopment of instructional materials or the time gaps between course repetitions.

10. When base or other support costs are presented, there is very little detail.

11. At this time, there appears to be more disparity than uniformity in costing approaches, in levels of details given, in categorization of systems used, and in cost areas included.

12. The diversity in approaches found in the literature may be due to the differing needs of the individuals involved in the training process: The initial planners in the principal development agency, the training development specialists, and those who manage and conduct the training operations.

REFERENCES

- Air Force Logistics Command. LSC model equations. Wright-Patterson Air Force Base, OH: Author, November 1975.
- Allison, S. L. The pilot training study: A cost-estimating model for undergraduate pilot training (RM-6083-PR). Santa Monica: Rand Corporation, December 1969. (AD-703 692)
- Army Electronics Command. Generalized electronics maintenance model (GEMM) for integrated logistic support (WRM-67-52). Fort Monmouth, NJ: Author, March 1975.
- Arzighian, S. On-the-job training costs: An analysis (WRM-67-52). Washington, DC: Naval Personnel Program Support Activity. June 1967. (AD-656 581)
- Bellanca, T. J. Cost effectiveness program plan for joint tactical communications. Volume III. Life cycle costing. Appendix D. Military personnel and training costs (TTO-ORT-032075-V3-AP-D). Fort Monmouth, NJ: Joint Tactical Communications Office, February 1975. (AD-A022 062)
- Berard, A. Life cycle cost management, methodology and case studies (Study Project Rep. PMC 77-22). Fort Belvoir, VA: Defense Systems Management College, October 1977.
- Boeing Company. Cost of ownership Document D675-10002, Appendix B. Seattle: Author, Undated.
- Boren, H. E., Jr., The pilot training study: A user's guide to the advanced pilot training computer cost model (APT) (RM-6087-PR). Santa Monica: Rand Corporation, December 1969. (AD-703 694)
- Braby, R. K., Henry, J. M., Parrish, W. F., Jr., & Swope, W. M. A technique for choosing cost-effective instructional delivery systems (TAEG-16). Orlando: Naval Training Equipment Center, April 1975. (AD-A012 859)
- Braby, R., Micheli, G. S., Morris, C. L., Jr., & Okraski, H. Staff study on cost and training effectiveness of proposed training systems (NAVTRAEQUIPCEN-TAEG-1). Orlando: Naval Training Equipment Center, 1972. (AD-748 593)
- Branson, R. K., Rayner, G. T., Cox, J. L., Furman, J. P., & King, F. J. Interservice procedures for instructional systems development: Executive summary and model. Tallahassee: Florida State University, Tallahassee Center for Educational Technology, August 1975. (a) (AD-A019 486)
- Branson, R. K., Rayner, G. T., Cox, J. L., Furman, J. P., & King, F. J. Interservice procedures for instructional systems development. Phase I: Analyze. Tallahassee: Florida State University, Tallahassee Center for Educational Technology, August 1975. (b) (AD-A019 487)
- Branson, R. K., Rayner, G. T., Cox, J. L., Furman, J. P. & King, F. J. Interservice procedures for instructional systems development. Phase II: Design. Tallahassee: Florida State University, Tallahassee Center for Educational Technology, August 1975. (c) (AD-A019 488)

Branson, R. K., Rayner, G. T., Cox, J. L., Furman, J. P., & King, F. J. Interservice procedures for instructional systems development. Phase III: Develop. Tallahassee: Florida State University, Tallahassee Center for Educational Technology, August 1975. (d) (AD-A019 489)

Branson, R. K., Rayner, G. T., Cox, J. L., Furman, J. P., & King, F. J. Interservice procedures for instructional systems development. Phases IV and V: Implement and control. Tallahassee: Florida State University, Tallahassee Center for Educational Technology, August 1975. (e) (AD-A019 490)

Branson, R. K., Rayner, G. T., Furman, J. L., & Cox, J. L. Interservice procedures for instructional systems development: technical level workshop. Tallahassee: Florida State University, Tallahassee Center for Educational Technology, December 1975. (AD-A023 892)

Brock, J. F. Issues in computer simulation in military maintenance training. Educational Technology, March 1978, pp. 41-45.

Bromberger, R. A. Procedures for acquisition and subsequent management of a maintenance training program (MTP) (NADC-77132-40). Warminster, PA: Naval Air Development Center, February 1977. (AD-B020 322L)

Clary, J. N. Training time and costs for Navy ratings and NECS (WRM-68-13). Washington, DC: Naval Personnel Program Support Activity, January 1968. (AD-667 578)

Clary, J. N., & Creaturo, J. T. Officer personnel costs: OCS, AOC, AVROC, NAVCAD, NROTC-C, NROTC-R, and Naval Academy (WOS-71-4). Washington, DC: Naval Personnel Research and Development Laboratory, March 1971. (AD-721 331)

Connelly, M. The feasibility of deriving a cost/effectiveness formula for man/machine function allocation (Rep. No. SRM 67-4). San Diego: Naval Personnel Research Activity, September 1966.

Connelly, M. A personnel cost data bank for use in studies of cost and effectiveness (Rep. No. SRM 68-3). San Diego: Naval Personnel Research Activity, August 1967.

Copeland, D. R., Nutter, R. V., Dean, C. F., Curry, T. F., Jr., & Morris, C. L., Analysis of commercial contract training (TAEG-13-1). Orlando: Naval Training Equipment Center, December 1974. (AD-A006 658)

Copeland, D. R., Nutter, R. V., Henry, J. M., Swope, W. M., & Curry, T. F., Jr., Analysis of commercial contract training for the Navy (TAEG-21-1). Orlando: Naval Training Equipment Center, June 1975. (AD-A016 890)

Daniels, R. W., & Cronin, J. E. Feasibility of automated electronic maintenance training (AEMT). Vol. II - Cost Analysis. Minneapolis: Honeywell, Inc., May 1975. (AD-A016 681)

Davis, R. W. Computer instruction: Basic hardware alternatives. National Society for Performance and Instruction Journal, November 1977, 16, 7-10.

DD 963 Integrated Logistic Support Plan. Initial Ship Manning Document, Requirements, Vol. 7, Part III, Section I. Source and date unknown.

Doughty, P., Stern H., & Thompson, C. Guidelines for cost effectiveness analysis for Navy training and education (NPRDC Spec. Rep. 76TQ-12). San Diego: Navy Personnel Research and Development Center, July 1976.

Dunham, A. D. Estimated cost of on-the-job training to the 3-skill level in the communications center operations specialty. Lackland Air Force Base, TX: Air Force Human Resources Laboratory, June 1972. (AD-753 093)

English, J. (Ed.). Cost-effectiveness: The economic evaluation of engineered systems. New York: John Wiley and Sons, Inc., 1968.

Fisher, G. H. Cost consideration in systems analysis. New York: American Elsevier, Inc., 1971.

Gay, R. M. Estimating the cost of on-the-job training in military occupations: A methodology and pilot study (R-1351-ARPA). Santa Monica: Rand Corporation, April 1974. (AD-783 936)

Gay, R. M. & Nelson, G. Cost and efficiency in military specialty training (P-5160). Santa Monica: Rand Corporation, January 1974. (AD-786 652)

Goodyear, B. J. Training equipment and building amortization study (WRM-65-10). Washington, DC: Naval Personnel Program Support Activity, June 1965. (AD-644 953)

Goodyear, B. J. Training equipment and building amortization study (WRM-66-29). Washington DC: Naval Personnel Program Support Activity, January 1966. (AD-643 845)

Hacket, J. M., Monroe, L. G., Galin, M. P., Marecki, S., & Schotzman, A. E. Life cycle cost/design-to-cost guidelines. Bedford, MA: The Mitre Corporation, June 1975. (AD-B006 916L)

Hall, E., Lam, K., & Bellamy, S. Training effectiveness assessment: Vol. I, current military training evaluation program (TAEG Rep. No. 39). Orlando: Naval Training Equipment Center, December 1976.

Hall, E., Rankin, W., & Aagard, J. Training effectiveness assessment: Vol. II, problems, concepts, and evaluation alternatives (TAEG Rep. No. 39). Orlando: Naval Training Equipment Center, Orlando: December 1976.

Johnson, S. L., Buckenmaier, C. C., Jr., & Sugarman, R. C. Instructional design for aircrew training. Buffalo, NY: Calspan Corporation, 1974.

Kollin, G. Army training costs: Phase I an examination of costs and recording practices at CONARC service schools (RAC-TP-204). McLean, VA: Research Analysis Corporation. May 1966. (AD-486 662)

Kyle, T. N., Graig, R. J., Fish, M. C., Liggett, W., & McCoy, F. The integrated facilities requirements study (IFRS) Phase III. Volume I. Summary (ORI-TR-645-Vol-I). Silver Springs, MD: Operations Research Inc., March 1971. (a) (AD-A037 050)

- Kyle, T. N., Craig, R. J., Fisk, M. C., Liggett, W., & McCoy, F. Development of the automated dynamic model for the integrated facilities requirements study (IFRS). Volume I. Summary of the dynamic management planning tool (ORI-TR-646-Vol-1). Silver Springs, MD: Operations Research Inc., March 1971. (b) (AD-A037 052)
- Kyle, T. N., Craig, R. J., Fisk, M. C., Liggett, W., & McCoy, F. Development of the automated dynamic model for the integrated facilities requirements study (IFRS). Volume II. Dynamic model user's manual (ORI-TR-646-Vol-2). Silver Springs, MD: Operations Research Inc., March 1971. (c) (AD-A037 053)
- Kyle, T. M., Craig, R. J., Fisk, M. C., Liggett, W., & McCoy, F. Development of the fleet air readiness requirements study (IFRS) phase III. Volume I. Summary of the fleet readiness training (FRT) management planning tool (ORI-TR-648-Vol-1). Silver Springs, MD: Operations Research Inc., March 1971. (d) (AD-A037 057)
- Kyle, T. N., Craig, R. J., Fisk, M. C., Liggett, W., & McCoy, F. Development of the fleet air readiness training model for the integrated facilities requirements study (IFRS) phase III. Volume III. FRT user's manual (ORI-TR-648-Vol-3). Silver Springs, MD: Operations Research, Inc., March 1971. (e) (AD-A037 058)
- Kyle, T. M., Craig, R. J., Fisk, M. C., Liggett, W., & McCoy, F. Development of the fleet air readiness training model for the integrated facilities requirements study (IFRS) phase III. Volume IV. FRT programmer's manual readiness training (FRT) management planning tool. (ORI-TR-648-Vol-4). Silver Springs, MD: Operations Research Inc., March 1971. (f)
- Lintz, L. M., Loy, S. L., Hopper, R., & Potempa, K. W. Relationships between design characteristics of avionics subsystems and training cost, training difficulty, and job performance. East St. Louis, MO: McDonnell Douglas Astronautics Co., January 1973. (AD-759 583)
- Littleton, L. The pilot training study: A user's guide to the undergraduate pilot training computer cost model (RM-6084-PR). Santa Monica: Rand Corporation, December 1969.
- Litton Industries, Ingalls Shipbuilding Division. Crew scheduling and phasing plan DD 963 Class Ships (ID No. DD-71-021). Pascagoula, MS: Author, January 1974.
- Litton Industries, Ingalls Shipbuilding Division. Training Course Plans for DD 963 Class Ships (ID No. DD-72-008). Pascagoula, MS: Author, July 1975.
- Litton Systems, Inc. Cost of Ownership (Pub. No. ILS-68009). Monterey, CA: Author, October 1976.
- Martin, J., Koehler, E. Mairs, L., & Hogan, P. Life cycle Navy enlisted billet cost tables - FY 77 (NPRDC Spec. Rep. 77-16). San Diego: Navy Personnel Research and Development Center, September 1977.
- McLachlan, J. C. Instructional systems development--A new approach to flight-crew proficiency, Naval Research Reviews. Washington, DC: Office of Naval Research, January 1977.

Mirabal, T. E. Forecasting future training costs, Training and Development Journal, July 1978, 32, 78-87.

Mission Analysis Study Group. Mission analysis on future undergraduate pilot training: 1975 through 1990. Volume 5. Appendix I: Evaluation of alternative future VPT systems. Appendix UPT mission analysis findings. Randolph Air Force Base, TX: January 1972. (AD-900 240)

Naval Weapons Engineering Support Activity, Logistics Engineering Department. Naval life cycle cost guide presenting the Naval Material Command life cycle cost methodology. Washington, DC: Author, March 1975.

Orlansky, J., & String, J. Cost-effectiveness of flight simulators for military training. Vol. I use and effectiveness of flight simulators (Rep. No. P-1275). Arlington, VA: Institute for Defense Analyses, Science and Technology Division, August 1977. (a)

Orlansky, J., & String, J. Cost-effectiveness of flight simulators for military training. Vol. II estimating cost of training in simulators and aircraft (Rep. No. P-1275). Arlington, VA: Institute for Defense Analyses, Science and Technology Division, August 1977. (b)

Ottaviano, D. A. Proposed ten-year plan for aerial target development and utilization. Navy aerial target procurement and inventory (NADC-72072-VT-REV-A-VOL-10). Warminster, PA: Naval Air Development Center, March 1973.

Patterson, M. L. Integrated logistic support costs. McClean, VA: Research Analysis Corporation, February 1971. (AD-880 878)

Perschbacher, P. G. Life cycle costs in the acquisition of weapon system (NMC-TP-74-21). Washington, DC: Naval Material Command, April 1974.

Petruschell, R. L. Modia applied in the design and cost analysis of an innovative Air Force course (R-1021-PR). Santa Monica: Rand Corporation, December 1972.

Reif, H. G. & Ring, W. F. H. B-1 systems approach to training. Volume II. Appendix A. Cost details (CALSPAN-FE-5558-N-1-VOL-2, CALSPAN-TM-SAT-1-VOL-2). Buffalo, NY: Calspan Corporation, July 1975. (AD-B007 209)

Rhode, W. E., Esseff, P. J., Pusin, C. J., Quirk, R. B., & Shulik, R. Analysis and approach to the development of an advanced multimedia instructional system. Volume II. Appendix III, Media Cost (AF-686F). Blandensburg, MD: Westinghouse Learning Corporation, May 1970. (AD-715 330)

Rome Air Development Center. Mathematical model and computer program for warranty economic analysis. Appendix F to Guidelines for Application of Warranties to Air Force Electronic Systems (RADC TR-76-32). Rome, GA: Author, 1976.

Samers, B. N., Dunham, A. D., & Nordhauser, F. The development of a methodology for estimating the cost of Air Force on-the-job training. Stamford, CT: Cooper and Co., July 1974. (a) (AD-785 141)

Samers, B. N., Dunham, A. D., & Nordhauser, F. Evaluation of methodology for estimating the cost of Air Force on-the-job training. Stamford, CT: Cooper and Co. November 1974. (b) (AD-A005 298)

Schumacher, S. P., Pearlstein, R. B., & Martin, P. W. A comprehensive key word index and bibliography on instructional system development. Valencia, PA: Applied Science Associates Inc. February 1974. (AD-777 192)

Spangenberg, R. W., Riback, Y., & Moon, H. L. The state of knowledge pertaining to selection of cost-effective training methods and media (HUMRRO-TR-73-13). Alexandria, VA: Human Resources Research Organization, June 1973. (AD-763 194)

Sugarman, R. C., Buckemaier, C. C., Jr., & Johnson, S. L. Systems approach to training (SAT) for the B-1 aircrew. Buffalo, NY: Calspan Corporation, 1974.

Sugarman, R. C., Johnson, S. L., Mitchell, J. F., Hinton, W. M., Jr., & Fishburne, R. P., Jr. E-2C systems approach to training, Phase I. Buffalo, NY: Calspan Corporation, December 1976. (AD-A036 264)

Swope, W. A Primer on economic analysis for naval training systems. (TAEG Rep. No. 31). Orlando: Naval Training Equipment Center, March 1976.

Taylor, J. L. LHA life cycle costing: A methodology (WRM 68-28). Washington, DC: Naval Personnel Program Support Activity, June 1968. (AD-681 742)

Walker, G. A. Life cycle cost/system effectiveness evaluation and criteria (D-180-17648-1). Seattle, WA: Boeing Company, January 1974. (AD-916 001)

Weiher, R., & Horowitz, S. A. The relative costs of formal and on-the-job training for Navy enlisted occupations (CNA professional paper 83). San Ramon, CA: Aerojet General Nucleonics, Research Division, November 1971. (AD-734 857)

Weinberg, G. Army training cost study. McLean, VA: Research Analysis Corporation, July 1967. (AD-831 767L)

Weingarten, K., Hungerland, J. E. & Brennan, M. F. Development and implementation of a quality-assured peer-instructional model (HUMRRO-TR-72-35). Alexandria, VA: Human Resources Research Organization, November 1972. (AD-753 601)

Weingarten, K., Hungerland, J. E., Brennan, M. F., & Allred, B. The development of a low-cost performance-oriented training model (HUMRRO Professional Paper-32-70). Alexandria, VA: Human Resources Research Organization, December 1970. (AD-722 273)

Weingarten, K., Hungerland, J. E., Brennan, M. F., & Allred, B. The APSTRAT instructional model (HUMRRO Professional Paper-6-71). Alexandria, VA: Human Resources Research Organization, May 1971. (AD-725 567)

Weingarten, K., Hungerland, J. E., Brennan, M. F., Allred, B. & Pollyea, M. Functional context training in an operational system (HUMRRO Professional Paper-8-70). Alexandria, VA: Human Resources Research Organization, March 1970. (AD-706 337)

Wethy, R. B., & Bumbak, A. Utilization costs of capital resources used by Navy training schools: A methodology (WRM-71-44). Washington, DC: Naval Personnel Research and Development Laboratory, June 1971. (AD-727 102)